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STATISTICAL STUDIES OF RECORDED ENERGY EXPENDITURE OF MAN

PART I

Basal Metabolism Related to Sex, Stature, Age, Climate and Race

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PREFACE

THIS investigation arose from the request of Dr. W. R. Aykroyd, Director of the Nutrition Division of the United Nations Food and Agriculture Organization, to its Standing Advisory Committee on Nutrition at its meeting in Geneva in 1947 for advice on the formulation of energy requirements of different populations for use in relation to estimates of food supplies and the preparation of production programmes. Advice was needed particularly in respect of possible differences in national requirements attributable to differences in the age constitution of populations, to race, or to climate. A preliminary review of the literature showed that no reliable opinion could be given quickly and the idea was conceived of assembling the data and having a statistical analysis made. Mr. Maurice Quenouille, Lecturer in Statistics at Aberdeen University, was consulted and he consented to make a regression analysis of the available data. Dr. W. B. Fisher, Lecturer in Geography at Aberdeen University, was then asked whether he could supply data on climate for the areas in which metabolism studies had been made, and he also consented to collaborate.

The investigation was planned in three stages: (1) basal metabolism; (2) expenditure on exercise, and (3) occupational expenditures. The data on basal metabolism were assembled by Mrs. F. C. Aitken, Miss E. D. Baird and Miss J. L. S. Ridley of the Bureau staff. The statistical work on this first part has taken approximately two years; work on the second part has just begun.

The analysis now reported, giving the association of basal metabolism with sex, stature, age, climate and race, is a first attempt to present a unified picture of these relationships as far as they can be distinguished from existing data. Certain general trends and differences have been made clear. There are aberrant groups of people, for instance Australian aborigines, Somalis, and the Hwa Miao Chinese, that differ significantly from both European or North American and most Asiatic peoples and about whom appropriate notes are given. The general picture may be accepted as referring to ordinary people about their everyday business and may serve as a guide until further and better data are forthcoming.

The statisticians were given no information at all, from comments in the original publications, about what were considered "normal" or "abnormal" rates in relation to North American standards. Most of the data singled out as aberrant relate to groups judged "abnormal" by these standards. On the other hand, failure to explain to the statisticians that Benedict meant by the now discarded term "Caucasians" people of European descent gave rise to some confusion. Small groups of control subjects of European origin, called Caucasians, were included in studies of Asiatics and S. American Indians, and one group of 15 "Caucasian" women was identified and included in the final analysis of European and U.S. subjects but, of several racial groups in Hawaii, some "Caucasians" were finally included with the Hawaiians. Because of the complexity of the problem and the process of statistical sifting of the data certain other small groups have been omitted from the main computations, but none of these omissions would much affect the results.

We have to thank Dr. A. F. Munro for a batch of unpublished data on British airmen in India which was used; and Madame G. Duprat, Muséum National d'Histoire Naturelle, Paris, for photostat copies of data not, as far as I know, available in this country. Unfortunately the analysis of data for adults had reached an advanced stage before these copies were received and only some data for children in Cuba (Coro, 1930) were used. References to the others are included in the bibliography.

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STATISTICAL STUDIES OF RECORDED ENERGY EXPENDITURES OF MAN

PART I

BASAL METABOLISM RELATED TO SEX, STATURE, AGE, CLIMATE AND RACE

General Introduction

The assembling of data was planned on the basis that the work should conform to certain simple requirements. The data must include (*a*) the geographical area in which the subjects were resident and (*b*) the race, sex, age, height and weight of each subject, or either height or weight and surface area, computed according to a stated formula, so that the missing measurement could be calculated. (*c*) The subjects must be ordinary, presumably healthy, people. (*d*) The method used to estimate basal metabolism should preferably be one of those generally accepted as capable of giving reliable results. In effect this ruling amounted to drawing a line at or about 1914, with the work of Benedict. The methods used have not been recorded in detail, nor is it suggested that the safeguard applied is sufficient to guarantee accuracy of the data used, or even to make all the data strictly comparable. For instance, Hafkesbring and Borgstrom (1926) and Wising (1934) claim a minimum metabolic rate at about 17 or 18 hours after the last meal, which is a longer interval than is usual. Neither that interval nor the interval of repose before the estimation has always been strictly standardised, and where only single studies were made the minimum attainable with training would not be reached. Nevertheless, the measure of uniformity has been such as to make it possible, with allowances for stature and climate, to single out what appear to be significant differences between racial groups of subjects. Where the method used might be of importance in relation to discrepancies discovered, it is reported in the text.

A number of investigations could not be used because of omission of one or more of the essential items in (*b*). For instance, in a number of papers basal metabolic rate is given only in terms of surface area, *e.g.*, Conklin and McClendon (1930); or as a percentage of some conventional standard (not listed); or only averages for groups of subjects are given, *e.g.*, Coons (1931). The restriction to ordinary subjects (*c*) greatly reduced the total volume of data because many studies deal only with sick or apparently abnormal people. Tables 1, 2, 3 and 4 show the data used for the main computations on adults; Table 11, the data for children; and the additional sources of data for adults over 40 years of age are shown on page 11.

It has long been an accepted convention in human physiology and medicine that basal metabolic rate may be more closely related to "surface area", expressed as a function of height and weight, than to a function of either height or weight separately. The formula most widely used for surface area is that of Du Bois (1927, p. 121):

$$A = 71{\cdot}84\, H^{0{\cdot}725}\, W^{0{\cdot}425}$$

where A is surface area in square centimetres, H is height in centimetres and W is weight in kilograms. On the other hand, it has been argued that no better approximation is given by this elaborate formula than by a simple power of weight. Those most often used are of the order of 0·7 to 0·75 (Brody, 1945; Kleiber, 1947). Such a formula has obvious

advantages. Weight is more easily measured than height. The examples appended to this analysis (p. 12; Table 22) show a few observed basal metabolic rates and the predictions on different bases.

There is, as far as we know, no accepted formula by which " climate " may be represented in respect of its physiological effects. We do not know how many separate parts of " climate " may affect metabolism. Neither effective temperature nor equivalent temperature as defined for the study of environment in enclosed spaces (Bedford, 1946) seems to be readily applicable to the study of natural environments and, even if an appropriate composite measure could be devised, the necessary data do not exist. That being so we decided, in consultation with Dr. Fisher, to use only temperature and humidity. The original papers did not always, or often, state at what time of the year, or under what climatic conditions, normal or abnormal, the studies were made. Nor did it appear that the conditions prevailing when an experiment was made would necessarily reflect long-term effects of climate on metabolism. Since our interest was in broad geographical trends, if such could be distinguished, we decided to use mean annual dry-bulb temperature and relative humidity (see Table 23).

It seemed possible, and even probable, that the effect of a given temperature might be altered by a change of humidity, or that the effect of a given humidity might change with temperature. To test this an extra term was introduced into the statistical equations, namely, the product of temperature and humidity (th).

In the simplest words possible, the principle of analysis is this. A group of subjects is chosen, of the same " race " and sex, and, in the first place, within arbitrary limits of age. An equation is set up, including terms for all the variables to be investigated, and that equation is used to predict basal metabolism. The known ages, heights, weights, and other data are inserted and the goodness of fit is tested. If, for instance, it is found that, when referred to the individual members of the group, the fit is better at the younger ages and less good at the higher, then metabolism changes with age and the prediction must be altered to take account of that.

In the study of the behaviour of metabolism as related to height and weight, the hypothesis was tested that a linear function of height and weight might give as good an answer as Du Bois's formula. To this end, height, weight and Du Bois surface area were all included in the equation. If, when the equation is fitted to the data, a large part of the variation is attributable to the term surface area, then it is clear that the relationship of body size to metabolism is more complex than can be expressed in simple, linear, terms of height and weight.

In the same way, the relative importance of each of the other terms in the equation can be measured.

The form of the equation used was as follows :

$$M = \alpha H + \beta W + \gamma S + \xi t + \eta h + \zeta th + \text{a constant}$$

$$\left(\text{or } \alpha H + \beta W + \gamma S + \zeta\left(t + \frac{\eta}{\zeta}\right)\left(h + \frac{\xi}{\zeta}\right) + \text{a constant}\right)$$

where M is the estimated basal metabolism in Calories per day, H height in cm., W weight in kg., S surface area in sq. m., t temperature in °F., h relative humidity per cent., th the product of temperature and humidity. Surface area throughout is according to the Du Bois formula.

The preliminary steps involved tentative classifications of data and tests of their validity, progress by trial and error.

Adults

Subdivision of the Data

First, the data were divided according to sex. After scrutiny only individuals aged 17 to 39 were considered for the first analysis. To decide upon further subdivisions, the data from North America were analysed separately and compared with the data for Europeans. There was reasonable agreement between these and they were combined. It was then found that Europeans resident in India, China and South America could be included, but the Italian data did not agree and were excluded.

Inspection of the rest showed that the data for Australian aborigines and Somalis, with values in Calories for 24 hours up to 2800 for aborigines and over 2000 with wide variations for Somalis, could not be included, and those for Italians in Somaliland, described only as "of military age" and also showing great variation, were rejected.* The remainder, including Italians in Italy, appeared to be fairly homogeneous and was analysed tentatively in one block.

First Results and their Interpretation

Table 5 gives the mean measurements for each of the four main groups into which data were divided for the first analysis. It may be seen that the mean weights and heights of the individuals in the U.S.–N. European groups were slightly greater than those in the other groups. There was an average difference of about 20° F. in mean temperature between these pairs of groups and a difference of about 10 per cent. in humidity. The basal metabolic rates for the women were much less than those for the men, about three-quarters.

The regression analyses were then made to estimate the effect of changes in body measurements and climate on basal metabolic rates. The results are shown in Table 6. Approximate standard errors are given for each of the regression coefficients, but these standard errors should be taken as underestimating the possible inaccuracy of some of the coefficients, since they have been calculated on the assumption that the individual observations were independent. This is not true, for instance, for temperature and humidity since many observations were made in the same locality. In consequence, these standard errors are likely to be too low for the temperature and humidity coefficients, but for the height, weight and surface area coefficients they may be taken as indicating, roughly, the inaccuracies of these values.

Certain conclusions may be drawn immediately from this table :

(1) In respect of the body build coefficients the U.S. and N. European men and women behave similarly. In both, the coefficients for height and weight are relatively large and the coefficient for surface area is small in relation to the variation in surface area. For instance, a change of 10 or 20 kg. in weight will cause a change of 100 or 200 Calories in basal metabolic rate. A comparable change of 0·1 or 0·2 sq. m. in surface area will cause only a negligible change in basal metabolic rate. It would appear that for the U.S.–N. European men and women the use of surface area does not much improve the estimate of basal metabolic rate obtained from the linear formula employing height and weight only.

(2) In respect of the body build coefficients the men and women of the second group also behave similarly. Surface area appears to play a larger part. The coefficient for surface area in both is fairly large, and the additional contribution from weight is large. Height contributes very little in addition to weight and surface area.

* This group showed an average rate about 240 Calories above prediction on the basis of Italians in Italy.

(3) For both the U.S.–N. European and mixed groups the coefficients for body build tend to be lower in women than in men. This appears to be in line with the difference between the basal metabolic rates shown in Table 5.

(4) The coefficients indicating the climatic effects are similar for all groups except U.S.–N. European women. In all, the *th* coefficient is small and inaccurate. For this reason the term was tentatively dropped and the regression coefficients were recalculated. These are given in Table 7. It may be seen that the effects of the body measurements have not been greatly altered, but the temperature and humidity coefficients have been greatly changed by the omission of the product term.

As a further step in the analysis the mean metabolic rates for men and women with comparable weights and heights were compared. This was done by adjusting the means to common weights and heights using the regression equations. It was found that the metabolic rate of women was approximately seven-eighths that of men. In addition, a further investigation showed that this ratio held approximately for the regression coefficients also, *i.e.*, a change of 1 kg. in weight of women produced about seven-eighths the effect of a change of 1 kg. in men. A joint regression was therefore estimated for men and women on the assumption that the metabolism of women was about seven-eighths that of the men. These regressions are given in Table 8.

This operation was completed roughly and rapidly since it was first necessary to have formulae which could be used to examine the internal consistency of the data. By comparing the observed mean metabolic rates with those calculated by these formulae any data of an unusual nature could be detected. These could then be eliminated before an accurate analysis was made of the remainder and the data excluded could subsequently be examined more closely.

The next stage was therefore to compare the observed mean metabolic rates with those calculated by the formulae of Table 8. The results are shown in the primary tables, 1 to 4, of which 2, 3 and 4 were one group at this stage, the " mixed " group.

The observed and the predicted metabolic rates for U.S.–N. European men and women (Table 1) were in fairly good agreement but there were one or two large differences. Of these, three among the men were for very small groups of 2, 7 and 9 subjects and the third of these, Eijkman's (1896) data, were estimations by the Zuntz-Geppert apparatus which has been criticised by Ozorio de Almeida (1924) as giving results that are too high. Du Bois (1927, p. 90) says it is accurate in the hands of trained and careful men but " . . . It would not be polite to name all who have failed ". Among the women, one was a small lot of American Indians, included in this group by mistake and subsequently identified and removed. There was no obvious reason to regard as other than genuine the differences in the Wising data for Swedish men (Krogh recording spirometer, 15 to 18 hr. post-absorptive interval, rest at least 45 min., minimum values) or the Harris and Benedict data for Michigan women.

For the second " mixed " lot, the differences between observed and predicted metabolic rates were such as to distinguish certain groups. The predictions for Indian, Chinese and Japanese subjects (Table 3) were too high except for the sub-group of the Hwa Miao Chinese (see note on p. 18). The data for Brazilian men (Table 4) were not in good agreement but there was no reason to question the technique with Tissot spirometer and Haldane gas analysis. There was no other definite dividing line. Since the Italian data formed a large group, it was decided to analyse them separately. The " mixed " group was therefore split into the three sub-groups shown in Tables 2, 3 and 4.

While this first analysis was in progress some additional data came to hand and were included in the further analysis. These appear in Tables 1 to 4, but without data for the first prediction.

Completion of the Analysis for Adults

At this stage the *th* coefficient was finally discarded for the reasons given above and, since the effects of temperature and humidity did not differ significantly from group to group, the information for all groups was combined to give the overall measure of their effect on basal metabolism. To estimate the effect of body size, the sexes were combined on the seven-eighths basis described above; the U.S.–N. European and Italian groups were taken as one, and the Asiatic and residual groups as one. The resulting equations, adjusted to a temperature of 70° F. and relative humidity 75 per cent., are shown in Table 9. With these, prediction tables for men and women, in terms of height and weight, were prepared for each of the two chief groups with adjustments for the other two (Tables 13 and 14, men, and 16 and 17, women). Subsidiary tables (Tables 15 and 18) give the corrections for different temperatures and humidities.

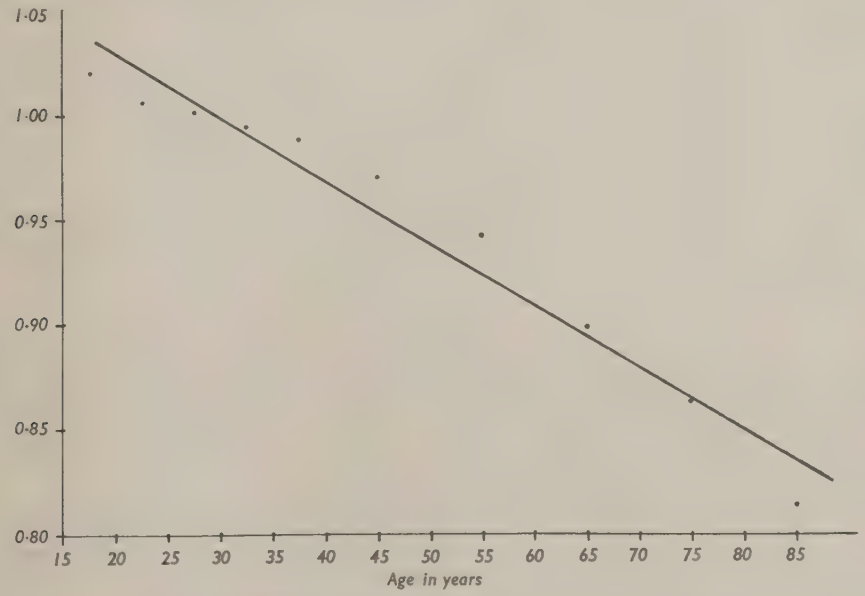

FIG. 1.—Ratio of Observed to Predicted Basal Metabolism by Age.

To find the effect of age on basal metabolism, the data already used were combined with data for older people: those of Benedict and Meyer (1932) for 23 women, U.S.; Matson and Hitchcock (1934), 14 men and 6 women, U.S.; Kisé and Ochi (1934), 44 men and 50 women, Japan; Lewis, W. H. (1938), 100 men, U.S.; and the people over 39 years of age from several of the other investigations. The numbers of observations in each of the groups are shown, by decades, in Table 10.

Basal metabolism was computed from the prediction equations for each of these age groups and the results were compared with the observed mean rates. The ratio of observed

to predicted was approximately 1 about age 30, rose below that age and fell above it to a minimum of about 0·8 in the highest age group. The mean ratios are plotted against age in Fig. 1. The points lie closely about a line which gives a rate of change, between age 17 and age 85, of 3 per cent. per decade of the metabolism at age 30 ; and this rate was subsequently shown to be applicable to children also. Table 19 shows the adjustments to be made for age, on the basis of 3 per cent. change per decade, the height-weight prediction table representing age 30.

Children

The numbers of children in the several age groups were so small that it was impossible to set up separate equations. The experiment was therefore made of applying the adult equations to the data for children. The list of data used is shown in Table 11.

Table 12 shows, first, the observed and predicted metabolism rates for U.S.–N. European children, in yearly age groups, and the ratios of observed to predicted rates. Down to age 3 the agreement was good except that the predicted rates for girls were a little low. An adjustment was made for this and the second prediction, giving an overall ratio of 1 : 1·001, shows that the error has been corrected. The number of children under 3 is not sufficient to allow of separate computations for them.

There is no evidence of any significant change in basal metabolism at, or about, puberty.

Tables 20 and 21 are prediction tables for boys and girls from 3 to 16 years of age, in terms of height and weight. The table for boys is an extension of the table for men ; that for girls corresponds to the prediction table for women, modified to include the correction above. The predictions must be adjusted for temperature, humidity and age.

The data for Asiatic children differed widely from predictions on the basis of the equations for Asiatic adults ; indeed they showed better agreement, at early ages, with predictions on the U.S.–N. European basis. Numbers were not sufficient to make it worth while to explore this problem further.

Examples

To facilitate sorting, the data for this analysis were transcribed, individually, to slips of different colours for adults and children and for males and females. Unfortunately the green for men and the blue for boys were on two occasions confused in artificial light. As a result Lenti's (1937) 525 Italian men and Stark's (1935) 55 Wisconsin students aged 17 and over were discovered among the children's data when the adult analysis had been completed. They therefore afford material for check computations.

The data for Lenti's men are as follows : mean height 166·5 cm., mean weight 61·00 kg., mean surface area 1·67 sq. m., mean age 22 years, temperature 66° F., humidity 53·5 per cent. The mean observed basal metabolism was 1629 Calories ; the prediction, corrected for temperature, humidity and age, is 1639 Calories. The ratio, observed to predicted, is 0·993.

For Stark's students the data are : mean height 179 cm., mean weight 69·4 kg., mean age 19 years, temperature 44° F., humidity 69 per cent. The basal metabolism, observed and predicted, was 1747 and 1796 Calories and the ratio, observed to predicted, is 0·973.

Miller and Benedict (1937) give data for 21 Samoan men, overlooked in the collection of data, whose mean height was 175 cm., mean weight 73·9 kg., mean surface area 1·889 sq. m., mean age 25 years, temperature 80° F., humidity 80 per cent. (as given in the original report). The mean observed basal metabolism was 1766 Calories. The predicted was 1718. The ratio, observed to predicted, is 1·028.

The following are examples taken at random from the age groups of adults.

U.S.–N. European men, number 155, height 175 cm., weight 65 kg., age 22, temperature 52° F., humidity 66 per cent., observed 1645, predicted 1677 ; ratio observed : predicted 0·981.

U.S.–N. European men, number 32, height 166 cm., weight 62 kg., age 85, temperature 51° F., humidity 58 per cent., observed 1305, predicted 1293 ; ratio observed : predicted 1·009.

U.S.–N. European women, number 48, height 164 cm., weight 67 kg., age 45, temperature 43·1° F., humidity 56 per cent., observed 1405, predicted 1384 ; ratio observed : predicted 1·015.

Italian men, number 152, height 167 cm., weight 66·8 kg., age 45, temperature 60° F., humidity 68 per cent., observed 1686, predicted 1633 ; ratio observed : predicted 1·032.

Italian women, number 29, height 157 cm., weight 59·8 kg., age 37, temperature 58° F., humidity 68 per cent., observed 1419, predicted 1411 ; ratio observed : predicted 1·006.

Asiatic and other men, number 34, height 160 cm., weight 54·9 kg., age 55, temperature 49° F., humidity 74 per cent., observed 1402, predicted 1405 ; ratio observed : predicted 0·998.

Asiatic and other women, number 53, height 155 cm., weight 50·6 kg., age 27, temperature 70° F., humidity 75 per cent., observed 1211, predicted 1217 ; ratio observed : predicted 0·995.

The following examples are for *individuals* taken at random from the data to illustrate the use of the tables.

American woman, height 173 cm., weight 79 kg., age 33, temperature 49° F., humidity 61 per cent. Basal metabolism for 24 hours, from Table 16, 1541 Calories. Corrections : for temperature +74, humidity −37. Total 1578. Correction for age −0·9 per cent., −14. Prediction 1564. Observed 1633. Ratio observed : predicted 1·044.

Italian man, height 170 cm., weight 72·5 kg., age 20, temperature 60° F., humidity 66 per cent. Metabolism from Table 13, 1650 Calories. Corrections : for Italian +130, temperature +40, humidity −27. Total 1793. Correction for age, +3 per cent., +54. Prediction 1847. Observed 1885. Ratio observed : predicted 1·021.

Japanese woman, height 148 cm., weight 42·7 kg., age 69, temperature 57° F., humidity 77 per cent. Metabolism from Table 17, 1106 Calories. Corrections : temperature +46, humidity +5. Total 1157. Correction for age, −11·7 per cent., −135. Prediction 1022. Observed 1022.

Filipino man, height 156 cm., weight 44·6 kg., age 48, temperature 81° F., humidity 79 per cent. Metabolism from Table 14, 1296 Calories. Correction for mixed group +60, temperature −44, humidity +12. Total 1324. Correction for age, −5·4 per cent., −71. Prediction 1253. Observed 1237. Ratio observed : predicted 0·987.

These examples are collected in Table 22, with estimates made by the formula of Du Bois, one of the formulae proposed by Brody, and Kleiber's general formula, showing for each the ratio of observed to predicted rates. In the second Kleiber estimates the first have been corrected for age on the basis of a rate of change of 4 per cent. per decade from age 30, as derived by him from data of Harris and Benedict (1919).

Aberrant Groups

Australian Aborigines

Data are available for 8 men from Wardlaw and Horsley (1928) and 9 men from Wardlaw and Lawrence (1932), for 21 men and 7 women from Hicks, Matters and Mitchell

(1931), for 33 men, " in the savage state ", from Hicks and Matters (1933) and for 10 men from Wardlaw, Davies and Joseph (1934). The ranges of metabolism in Calories for 24 hours in these four sets are : 1321 to 1986, 1223 to 1932 for men and 1077 to 1466 for women, 1379 to 2856 (25 over 2000, no age) ; and 864 to 1746. With a total of only 72 men (and 7 women) and a range from 864 to 2856, it did not appear worth while to attempt any analysis.

There are also data from Hicks, Matters and Mitchell (1931) for 10 boys and 12 girls.

Somalis

Camis (1936) records basal metabolism of 60 Somalis, whose ages are not given, with a range from 1374 to 4368 (!) Calories for 24 hours. It is stated on page 28 that conditions were not always such as " sono necessarie per una respirazione calma e per il buon esito della observazione ".

Hwa Miao Chinese

The mean observed metabolism for 24 hours was 1475 Calories and the first predicted rate was 1403 (Table 3). That is to say, the rate was 72 Calories above prediction and Kilborn and Benedict (1937*b*) comment that, with a high metabolism and a low pulse rate, the Hwa Miao resembles the Maya Indian.

Five groups of American Indians were analysed. These, in the order in Table 4, show excesses over prediction of 105, 102, 134, 115 and 90 Calories for 24 hours. The pulse rates in the first two series were about 60 for men and 67 for Mapuche women ; in the Maya Indians rates varied, usually between 40 and 65, and between 40 and 79 in the last series, in which the control N. Americans had rates between 52 and 94. The average pulse rate of the Hwa Miao Chinese subjects was 55, which is the same as that recorded for Samoan men.

We had hoped to have also data for Arabs in Libya and more data for Brazilians from work done by De Castro, but the two papers by Genna (1937 ; 1938), reproduced for us by Madame Duprat, give the data only in terms of Calories per sq. m. per hour and those which De Castro sent did not include the necessary details.

Summary and Comments

A statistical analysis has been made of the records of basal metabolism of over 8600 subjects, of which roughly 4300 were between the ages of 17 and 39 years, nearly 800 aged 40 and over, and 3500 below 17 years of age. The analysis distinguishes differences due to sex, race, stature, climate as expressed in mean annual temperature and relative humidity, and age.

Equations have been derived from which to predict basal metabolism in Calories for 24 hours, and, because the equations are elaborate and differ for the two main racial groups distinguished, prediction tables are presented. The main distinctions and trends are as follows.

Sex. The basal metabolism of women has been found to be almost exactly seven-eighths (0·875) that of men *of the same height and weight.* The difference is slightly less between boys and girls.

This gives a bigger difference between the sexes than that suggested by the data reviewed by Du Bois (1927, p. 153) which is of the order of 5 to 9 per cent. It does not, of course, express the same relationship as that assessed by conventional man-value coefficients, usually

of the order of 0·8, which refer to total energy expenditure and take into account differences in stature and activity.

Race. The analysis distinguishes two main groups of people, each with two sub-groups. Subjects from the United States and N. Europe form one group. Italians belong to this group in pattern, but have a higher mean level of metabolism. Indians, Chinese and Japanese form the second main group. The Eskimo, American Indian, Polynesian and other races, except possibly Australian aborigines and Somalis, accord in type with the Asiatic group but exceed it in mean basal metabolism. Data for Australian aborigines and Somalis were so variable that no reliable comparison with other races could be made.

Stature. The relation of basal metabolism to stature is more complex than that expressed in the Du Bois formula, or by any simple function of weight, or of height and weight together. All three terms are used in the equations and their relative weights distinguish the main racial groups.

Prediction tables give basal metabolism in Calories for 24 hours in relation to height and weight, for adults aged 30 and for U.S.–N. European children, at 70° F. and 75 per cent. relative humidity. Asiatic children are aberrant. They more closely resemble U.S.–N. European children at early ages, and Asiatic adults later.

Climate. The prediction tables for metabolism in relation to height and weight have been prepared for a mean annual temperature of 70° F. and mean annual relative humidity of 75 per cent. Starting from these points, metabolism for 24 hours changes *inversely* with temperature at the rate of 4 Calories for 1° F. in men and boys and 3·5 Calories in women and girls ; and changes *directly* with humidity by 3 Calories for 1 per cent. in men and boys and by slightly less in women and girls (seven-eighths of the change in men).

The maximum effects are therefore produced by hot dry and by cold wet climates. For instance, the basal metabolism of a man of 66 kg. and 175 cm. in New York would be of the order of 1638 Calories, in the Canadian Subarctic about 1865 and in Hermannsburg (central Australia) about 1463. In areas where temperature and humidity are both high or both low, basal metabolism will differ little from the standard prediction. The opposite effects of high temperature and high humidity would explain why, in parts of the tropics, the metabolism of Europeans and N. Americans has been found to show little change from that in temperate regions.

Age. When all other variables have been taken into account, the massed data for adults of both sexes and all racial groups analysed, and for U.S.–N. European children, conform to the rule that basal metabolism declines at the rate of 3 per cent. per decade from age 3 to ages over 80. This is a higher rate of decline than that suggested by Aub and Du Bois (Du Bois, 1927, p. 200) which is just over 2 per cent. per decade in terms of metabolism per sq. m. surface area, from age 14 to 80. It is less than that, 4 per cent. per decade, deduced by Kleiber (1947) from re-analysis of the data of Harris and Benedict (1919).

In the combined data for U.S. and European children there is no evidence of any significant change in basal metabolism at, or about, puberty.

Subsidiary prediction tables give corrections for temperature, humidity and age.

TABLE 1

UNITED STATES AND NORTHERN EUROPEAN ADULTS, 17–39 YEARS OF AGE

Source	Area	No. of Observations	Mean		Metabolic Rates: Cal. Per Day		
			Height cm.	Weight kg.	Observed	First Prediction	Difference
Men							
Benedict *et al.*, 1914	Boston, U.S.A.	53	172·1	63·6	1621	1645	− 24
Benedict, 1928	,, ,,	19	175·5	70·8	1680	1724	− 44
Harris and Benedict, 1919	,, ,,	29	174·4	62·8	1614	1633	− 19
Benedict *et al.*, 1914	Michigan, ,,	12	170·2	57·5	1522	1572	− 50
Harris and Benedict, 1919	,, ,,	13	173·3	66·2	1680	1669	11
Benedict *et al.*, 1914	Syracuse, ,,	17	174·4	69·2	1834	1836	− 2
Boothby and Sandiford, 1922	Rochester, Minn., ,,	29	171·8	65·1	1700	1649	51
Griffith *et al.*, 1929	Buffalo, ,,	2	165·5	56·5	1301	1541	−240
Hafkesbring and Borgstrom, 1926	New Orleans, U.S.A.	7	174·4	63·6	1366	1574	−208
Remington and Culp, 1931	Charleston, U.S.A.	40	176·1	64·6	1596	1595	1
Cathcart and Orr, 1919	U.K.	9	168·4	62·0	1558	1599	− 41
Hobson, 1922	Oxford, U.K.	25	177·0	66·9	1745	1678	67
Wising, 1934	Stockholm	40	178·9	70·1	1621	1767	−146
Munro (unpublished)	Bombay	78	174·4	64·3	—	—	—
Rajagopal, 1938	S. India	20	173·0	62·2	1560	1561	− 1
Eijkman, 1896	Batavia	9	175·9	73·2	1794	1659	135
	Total	402					
Women							
Benedict *et al.*, 1914	Michigan, U.S.A.	11	160·6	53·1	1316	1304	12
Harris and Benedict, 1919	,, ,,	9	160·8	57·2	1487	1337	150
Benedict *et al.*, 1914	Boston, ,,	47	162·3	54·4	1358	1320	38
Benedict, 1928	,, ,,	23	161·6	59·1	1325	1353	− 28
Harris and Benedict, 1919	,, ,,	9	161·1	52·0	1239	1283	− 44
Gustafson and Benedict, 1928	Wellesley, ,,	20	164·3	58·3	—	—	—
Blunt and Dye, 1921	Chicago, ,,	11	159·8	60·6	1351	1320	31
Boothby and Sandiford, 1922	Rochester, ,,	43	160·9	59·2	1416	1352	64
Bricker *et al.*, 1945	Urbana, ,,	9	164·7	59·6	1300	1349	− 49
Griffith *et al.*, 1929	Buffalo, N.Y., ,,	3	161·3	55·0	1270	1320	− 50
Hardy *et al.*, 1941	New York, ,,	6	166·2	61·0	1315	1378	− 63
Hafkesbring and Borgstrom, 1926	New Orleans, U.S.A.	2	165·5	51·7	1142	1235	− 93
Lewis *et al.*, 1943	Denver, U.S.A.	43	167·1	54·5	1228	1276	− 48
McKay and Patton, 1936	Columbus, Ohio, U.S.A.	18	162·8	64·7	1377	1385	− 8
Remington and Culp, 1931	Charleston, U.S.A.	93	162·7	57·4	1336	1290	46
Shaw, 1933-34	S. Dakota, ,,	6	163·8	56·8	1436	1330	106*
Tilt, 1930	Florida, ,,	52	159·4	53·8	1236	1234	2
Wising, 1934	Stockholm	37	167·1	59·4	—	—	—
Mason, 1934	Madras	23	163·1	52·4	1207	1189	18
Williams and Benedict, 1928	Yucatan	7	155·8	46·9	—	—	—
Kilborn and Benedict, 1937*a*	China	15	160·0	57·4	—	—	—
	Total	487					

* American Indians: omitted.

TABLE 2

ITALIAN ADULTS, 17–39 YEARS OF AGE

Source	Area	No. of Observations	Mean		Metabolic Rates: Cal. Per Day		
			Height cm.	Weight kg.	Observed	First Prediction	Difference
Men							
Felloni, 1936	Rome	532	171·4	66·1	1707	1703	4
Granati and Busca, 1942	Carbonia	188			1708	1635	73
Occhiuto and Pepe, 1940	Naples	338			1738	1684	54
Pepe, 1938	Leghorn	252			1767	1732	35
Lenti, 1937 *	Mirafiori	525	166·5	61·0	—	—	—
	Total	1835					
Women							
Occhiuto and Pepe, 1939	Naples	191	157·5	57·0	—	—	—
Occhiuto and Cappelletto, 1939	Turin	70					
	Total	261					

* See text note, p. 12.

TABLE 3

INDIAN, CHINESE AND JAPANESE ADULTS, 17–39 YEARS OF AGE

Source	Area	No. of Observations	Mean		Metabolic Rates: Cal. Per Day		
			Height cm.	Weight kg.	Observed	First Prediction	Difference
		Men					
		Indian					
Krishnan and Vareed, 1932	Madras	61	167·5	53·6	1350	1391	− 41
Niyogi *et al.*, 1939	Bombay	24			1305	1396	− 91
Rahman, 1936	Hyderabad	32			1404	1436	− 32
Rajagopal, 1938	S. India	22			1330	1493	−163
		Chinese					
Benedict *et al.*, 1937	Peiping	35	168·9	57·8	1502	1621	−118
Benedict and Garven, 1936	Moukden	19	168·5	54·7	1439	1615	−176
Kilborn and Benedict, 1937*a*	Chengtu, Szechwan	50	165·2	52·4	1457	1517	− 60
Kilborn and Benedict, 1937*b*	Kweichow	20 [1]	154·3	46·1	1475	1403	72
		Chinese, Chinese × Hawaiian and Japanese					
Miller and Benedict, 1937	Hawaii	80 [2]	170·0	59·8	—	—	—
		Eurasian, Indian, Chinese, Japanese					
Oliveiro, 1937	Malaya	18 [3]	170·0	57·4	—	—	—
		Japanese					
Okado *et al.*, 1926	Tokyo	42	162·0	51·9	1426	1507	− 81
	Total	403					
		Women					
		Indian					
Krishnan and Vareed, 1932	Madras	15	153·5	44·9	1038	1107	− 69
Mason and Benedict, 1931	Madras	44			1048	1107	− 59
Niyogi *et al.*, 1939	Bombay	52			1055	1105	− 50
		Chinese					
Benedict *et al.*, 1937	Peiping	40	156·7	49·9	1239	1309	− 70
Kilborn and Benedict, 1937*a*	Szechwan	27 [4]	157·1	52·6	—	—	—
		Chinese and Japanese					
Siddall and Kwok, 1937	Canton	86	155·5	43·4	1157	1133	24
MacLeod *et al.*, 1925	U.S.A.	9	155·0	47·2	1147	—	—
Turner and Benedict, 1935	U.S.A.	10	157·0	45·6	1128	—	—
		Chinese, Chinese × Hawaiian and Chinese					
Miller and Benedict, 1937	Hawaii	59 [2]	157·6	47·0	—	—	—
		Japanese					
Okado *et al.*, 1926	Tokyo	11	149·7	49·3	1251	1276	− 25
	Total	353					

[1] This group is of Hwa Miao Chinese. They are omitted from further analyses.

[2] Miller and Benedict's data from Hawaii represent a mixed group of "Caucasians", Chinese, Japanese and Hawaiians which was subsequently split. The differences between observed and predicted rates for the whole group were: for men − 1 and women − 4.

[3] Oliveiro's data also were for a mixed group, later split. The difference for the group of men as a whole was 38.

[4] The Szechwan data are for "Caucasians" and Chinese and these were later separated. The Chinese women were inadvertently omitted after the separation.

TABLE 4

RESIDUAL MIXED GROUP: ESKIMO, AMERICAN INDIAN, BRAZILIAN, HAWAIIAN, FILIPINO, JAMAICAN AND INDONESIAN ADULTS, 17–39 YEARS OF AGE

Racial class	Source	Area	No. of Observations	Mean Height cm.	Mean Weight kg.	Metabolic Rates: Cal. Per Day Observed	First Prediction	Difference
			Men					
Eskimo	Crile and Quiring, 1939*a*	Canadian Subarctic.	21	162·5	63·0	1900	1929	— 29
	Rabinowitch and Smith, 1936	,, ,,	2			1848	1812	36
Maya-Quiché Indian	Crile and Quiring, 1939*b*	Guatemala	19	158·8	55·4	1617	1512	105
Mapuche Indian	Pi-Suñer, 1933	S. Chile	29 [1]		—	1796	1694	102
Maya Indian	Shattuck and Benedict, 1931	Yucatan	16			1532	1398	134
	Steggerda and Benedict, 1932	,,	29	157·7	53·8	1532	1417	115
	Williams and Benedict, 1928	,,	21			1505	1415	90
Brazilian	Galvão, 1948*b*	Brazil	76	176·1	67·6	1566	1706	— 140
Jamaican	Steggerda and Benedict, 1928	Jamaica	46	169·2	60·5	1527	1516	11
Hawaiian	Miller and Benedict, 1937	Hawaii	43 [2]	180·0	72·1	—	—	—
Filipino	Ocampo *et al.*, 1930	Philippines	15	164·2	58·1	1424	1455	— 31
Indonesian	Eijkman, 1896	Batavia	10			1515	1358	157
	Goewie and Radsma, 1937	,,	53	168·5	57·4	1409	1376	33
	Radsma, 1931	,,	50			1621	1571	50
Malay	Oliveiro, 1937	Singapore	5 [3]	165·6	54·4	—	—	—
		Total	435					
			Women					
Eskimo	Crile and Quiring, 1939*a*	Canadian Subarctic.	18	153·6	50·5	1670	1666	64
	Rabinowitch and Smith, 1936	,, ,,	2 [4]			1653	1493	160
Mapuche Indian	Pi-Suñer, 1933	S. Chile	13 [1]			1700	1461	239
Hawaiian	Miller and Benedict, 1937	Hawaii	67 [2]	162·6	57·6	—	—	
Filipino	Ocampo *et al.*, 1930	Philippines	17	156·4	47·3	1158	1140	18
		Total	117					

[1] This group of Mapuche Indians was omitted from further analysis because the women were so far out of line with the other women in the group.

[2] Miller and Benedict's data from Hawaii represent a mixed group of "Caucasians", Chinese, Japanese and Hawaiians, which was subsequently split. The differences between observed and predicted rates for the whole group were: for men −1, and women −4.

[3] Oliveiro's data also were for a mixed group, later split. The difference for the group of men as a whole was 38.

[4] This small group of Eskimo women was also omitted from further analyses because of their wide deviation from prediction.

TABLE 5

ESTIMATED MEANS FOR INITIAL ANALYSIS OF ADULTS AGED 17–39

Mean	U.S. and N. European		Mixed	
	Men	Women	Men	Women
Weight, *W*, kg.	65·3	56·5	63·0	49·0
Height, *H*, cm.	174·2	162·4	169·9	156·3
Surface Area, *S*, sq. m.	1·83	1·62	1·72	1·46
Temperature, *t*, °F.	46·7	49·8	63·7	69·4
Humidity, *h*, per cent.	64·9	56·4	69·5	75·7
Temperature × humidity, *th*	3054	2866	4466	5260
Basal Metabolic rate, *M*, Calories for 24 hours	1629	1317	1643	1207

TABLE 6

REGRESSION COEFFICIENTS ESTIMATED FROM INITIAL ANALYSIS OF ADULTS AGED 17–39

Coefficient For	U.S. and N. European		Mixed	
	Men	Women	Men	Women
Height, *H*	5·67 ± 1·07	3·24 ± 0·96	− 4·26 ± 1·32	1·35 ± 2·03
Weight, *W*	12·06 ± 1·05	8·30 ± 0·94	5·00 ± 1·81	6·00 ± 3·14
Surface Area, *S*	− 46·3 ± 68·9	40·9 ± 67·3	720 ± 154	382 ± 258·0
Temperature, *t*	− 27·65 ± 5·46	− 1·06 ± 2·86	− 22·82 ± 7·17	− 29·35 ± 9·32
Humidity, *h*	− 20·73 ± 3·96	6·29 ± 1·89	− 16·00 ± 5·70	− 6·91 ± 7·11
Temperature × humidity, *th*	0·364 ± 0·082	− 0·049 ± 0·042	0·236 ± 0·092	0·296 ± 0·122

TABLE 7

REVISED TABLE OF ESTIMATED REGRESSION COEFFICIENTS

Coefficient For	U.S. and N. European		Mixed	
	Men	Women	Men	Women
Height, *H*	4·47	3·08	− 4·34	1·59
Weight, *W*	12·12	8·42	5·11	6·41
Surface Area, *S*	− 38·2	36·5	717	340
Temperature, *t*	− 3·38	− 4·29	− 4·57	− 6·70
Humidity, *h*	− 3·11	4·24	− 1·52	10·20

TABLE 8

TABLE OF COMBINED REGRESSION COEFFICIENTS FOR MEN AND WOMEN

Coefficient For	U.S. and N. European	Mixed
Height, H . . .	3·17	− 3·24
Weight, W . . .	10·26	6·35
Surface Area, S . . .	57·6	615
Temperature, t . . .	− 3·81	− 5·76
Humidity, h . . .	2·26	0·08
Constant term . . .	, 359	1082

TABLE 9

REGRESSION EQUATIONS

(Adjusted to relative humidity 75 per cent., temperature 70° F.)

U.S. and N. Europeans

Men $M = 2{\cdot}975\,H + 8{\cdot}90\,W + 111{\cdot}7\,S + 3{\cdot}0\,h - 4{\cdot}0\,t + 293{\cdot}8$

Women $M = 0{\cdot}875\,\{2{\cdot}975\,H + 8{\cdot}90\,W + 111{\cdot}7\,S + 3{\cdot}0\,h - 4{\cdot}0\,t + 293{\cdot}8\} + 29{\cdot}7$

Italians

Men $M = 2{\cdot}975\,H + 8{\cdot}90\,W + 111{\cdot}7\,S + 3{\cdot}0\,h - 4{\cdot}0\,t + 423{\cdot}7$

Women $M = 0{\cdot}875\,\{2{\cdot}975\,H + 8{\cdot}90\,W + 111{\cdot}7\,S + 3{\cdot}0\,h - 4{\cdot}0\,t + 423{\cdot}7\} + 12{\cdot}5$

Indians, Chinese and Japanese

Men $M = -3{\cdot}075\,H + 5{\cdot}02\,W + 556{\cdot}6\,S + 3{\cdot}0\,h - 4{\cdot}0\,t + 771{\cdot}6$

Women $M = 0{\cdot}875\,\{-3{\cdot}075\,H + 5{\cdot}02\,W + 556{\cdot}6\,S + 3{\cdot}0\,h - 4{\cdot}0\,t + 771{\cdot}6\} - 4{\cdot}3$

Residual Mixed Group

Men $M = -3{\cdot}075\,H + 5{\cdot}02\,W + 556{\cdot}6\,S + 3{\cdot}0\,h - 4{\cdot}0\,t + 828{\cdot}2$

Women $M = 0{\cdot}875\,\{-3{\cdot}075\,H + 5{\cdot}02\,W + 556{\cdot}6\,S + 3{\cdot}0\,h - 4{\cdot}0\,t + 828{\cdot}2\} - 13{\cdot}7$

TABLE 10

NUMBERS OF MEN AND WOMEN IN EACH MAIN GROUP, CLASSIFIED BY AGE

Age Group	U.S. and N. European		Italian		Residual Mixed Group		Indian, Chinese and Japanese	
	Men	Women	Men	Women	Men	Women	Men	Women
20–29 . .	248	318	979	162	282	79	215	236
30–39 . .	61	107	166	71	88	15	34	22
40–49 . .	35	48	152	37	30	16	23	11
50–59 . .	29	43	75	13	8	5	26	17
60–69 . .	26	18	—	6	3	—	17	17
70–79 . .	26	17	—	—	1	—	10	18
80 + . .	32	14	—	—	1	—	7	8
Total .	457	565	1372	289	413	115	332	329

TABLE II

DATA USED FOR CHILDREN

Source	Area	Number of Observations
	United States and Northern European	
	Boys	
Benedict and Talbot, 1921	New England, U.S.A.	50
Talbot, 1936	Boston, U.S.A.	1
Olmstead *et al.*, 1918	New York, U.S.A.	14
Topper and Mulier, 1932	,, ,, ,,	28
Webster *et al.*, 1941	,, ,, ,,	132
Wang, 1939	Cincinnati, U.S.A.	13
Stark, 1935	Wisconsin, U.S.A.	7
Lewis *et al.*, 1937	Denver, U.S.A.	350
Lucas and Pryor, 1933	San Francisco, U.S.A.	24
Lamb, 1945	Texas, U.S.A.	17
De Bruin, 1931, 1939	Amsterdam	166
Bedale, 1923	Hampshire, England	1
Bruen, 1933	Germany	13
Harris and Benedict, 1919	,,	9
	Total	825
	Girls	
Benedict and Talbot, 1921	New England, U.S.A.	42
Talbot, 1936	Boston, U.S.A.	72
Talbot *et al.*, 1937		
Topper and Mulier, 1932	New York, U.S.A.	71
Webster *et al.*, 1941	,, ,, ,,	87
Wang, 1939	Cincinnati, ,,	55
Wang *et al.*, 1936	,, ,,	24
Blunt *et al.*, 1926	Chicago, ,,	79
Wang *et al.*, 1926	,, ,,	6
McKay, 1930	Ohio, ,,	45
Lewis *et al.*, 1937	Denver, ,,	262
Lucas and Pryor, 1933	San Francisco, U.S.A.	26
Lamb, 1945–46	Texas, U.S.A.	13
Nylin, 1935	Stockholm	141
Vogelius, 1945	Denmark	134
De Bruin, 1931, 1939	Amsterdam	135
Bedale, 1923	Hampshire, England	6
Bruen, 1933	Germany	43
Harris and Benedict, 1919	,,	6
	Total	1247
	Italian	
	Boys	
Pepe and Perrelli, 1937	Baia	264
Pepe and Rinaldi, 1936	Baia	216
	Total	480
	Girls	
Miani-Calabrese and Perrelli, 1937	Naples	85
Pepe and Perrelli, 1937	Baia	235
Pepe and Rinaldi, 1936	Baia	143
	Total	463

TABLE 11—*continued*

Source	Area	Number of Observations
	Indian, Chinese and Japanese	
	Boys	
Niyogi *et al.*, 1940	Bombay (Indian)	24
Wilson and Roy, 1937–38	Calcutta (Indian)	62
Oliveiro, 1939	Singapore (Malay)	143
Benedict and Garven, 1936	Manchuria (Chinese)	2
Kung *et al.*, 1939	Peiping (Chinese)	22
Wang and Hawks, 1932	Chicago (Chinese)	11
Nakagawa, 1934*a*, 1934*b*, 1935, 1937	Tokyo (Japanese)	93
	Total	357
	Girls	
Kung *et al.*, 1939	Peiping (Chinese)	17
Benedict and Meyer, 1933	Boston, U.S.A. (Chinese)	11
Siddall and Kwok, 1937	S. China (Chinese)	6
Nakagawa, 1934*a*, 1934*b*, 1935, 1937	Tokyo (Japanese)	138
	Total	172
	Eskimo	
	Boys	
Rabinowitch and Smith, 1936	Canadian Arctic	1
	Cuban	
	Girls	
Coro, 1930	Cuba	17

TABLE 12

OBSERVED AND PREDICTED BASAL METABOLIC RATES FOR UNITED STATES AND NORTHERN EUROPEAN CHILDREN: CALORIES PER DAY

	Boys				Girls					
Age	No. in Group	Observed	Prediction	Ratio	No. in Group	Observed	First Prediction	Ratio	Second Prediction	Ratio
1	14	637·7	833·6	0·763	15	620·7	769·5	0·807	—	—
2	42	751·3	810·1	0·927	52	702·4	715·9	0·981	—	—
3	64	848·6	863·9	0·982	63	771·1	762·4	1·011	782	0·986
4	58	887·1	893·2	0·993	51	830·1	805·7	1·030	826	1·005
5	65	946·8	942·6	1·004	49	867·7	860·5	1·008	884	0·982
6	58	981·2	988·9	0·992	59	939·2	909·8	1·032	929	1·011
7	55	1042·9	1036·8	1·006	57	990·5	969·5	1·022	988	1·002
8	68	1096·6	1103·9	0·993	61	1032·4	1028·7	1·004	1046	0·987
9	55	1136·3	1129·7	1·006	71	1064·5	1069·2	0·996	1083	0·982
10	62	1191·9	1176·3	1·013	88	1123·9	1124·1	1·000	1138	0·988
11	57	1236·3	1262·7	0·979	133	1218·2	1193·5	1·021	1205	1·011
12	66	1280·0	1309·8	0·977	155	1259·2	1227·4	1·026	1237	1·018
13	53	1382·6	1369·5	1·010	133	1325·2	1282·5	1·033	1282	1·033
14	47	1480·6	1456·1	1·017	113	1368·6	1338·1	1·023	1338	1·023
15	40	1587·4	1555·0	1·021	81	1360·7	1369·4	0·994	1369	0·994
16	21	1718·1	1733·3	0·991	77	1380·8	1393·8	0·991	1394	0·991
Overall mean				0·999				1·014		1·001

TABLE 13

PREDICTED BASAL METABOLIC RATES FOR U.S.–N. EUROPEAN MEN
(Age 30, Temperature 70° F., Relative Humidity 75 per cent.)

Weight in kg.	Height in cm.												
	140	145	150	155	160	165	170	175	180	185	190	195	200
40	1205	1223	1241	1260	1278	1297	1315	1333	1351	1370	1388	1406	1424
42	1225	1244	1262	1281	1299	1318	1336	1354	1373	1391	1409	1427	1446
44	1246	1265	1283	1302	1320	1339	1357	1375	1394	1412	1430	1448	1467
46	1267	1285	1304	1322	1341	1359	1378	1396	1415	1433	1452	1470	1488
48	1287	1306	1324	1343	1362	1380	1399	1417	1436	1454	1473	1491	1510
50	1307	1326	1345	1364	1382	1401	1420	1438	1457	1475	1490	1512	1531
52	1328	1347	1365	1384	1403	1422	1440	1459	1478	1496	1515	1533	1552
54	1348	1367	1386	1405	1424	1442	1461	1480	1498	1517	1536	1554	1573
56	1368	1387	1406	1425	1444	1463	1482	1500	1519	1538	1557	1575	1594
58	1389	1408	1427	1446	1464	1483	1502	1521	1540	1559	1577	1596	1615
60	1409	1428	1447	1466	1485	1504	1523	1542	1561	1579	1598	1617	1636
62	1429	1448	1467	1486	1505	1524	1543	1562	1581	1600	1619	1637	1656
64	1449	1468	1487	1506	1526	1546	1564	1583	1602	1621	1639	1658	1677
66	1469	1488	1507	1527	1546	1565	1584	1603	1622	1641	1660	1679	1698
68	1489	1508	1527	1547	1566	1585	1604	1623	1642	1662	1681	1699	1718
70	1509	1528	1548	1567	1586	1605	1625	1644	1663	1682	1701	1720	1739
72	1529	1548	1568	1587	1606	1626	1645	1664	1683	1702	1721	1740	1760
74	1549	1568	1588	1607	1626	1646	1665	1684	1704	1723	1742	1761	1780
76	1568	1588	1607	1627	1646	1666	1685	1704	1724	1743	1762	1781	1801
78	1588	1608	1627	1647	1666	1686	1705	1725	1744	1763	1783	1801	1821
80	1608	1628	1647	1667	1686	1706	1725	1745	1764	1784	1803	1822	1841
82	1620	1648	1667	1687	1706	1726	1745	1765	1784	1804	1823	1842	1862
84	1648	1667	1687	1707	1726	1746	1765	1785	1804	1824	1843	1862	1882
86	1667	1687	1707	1727	1746	1766	1785	1805	1825	1845	1863	1882	1902
88	1687	1707	1727	1746	1766	1786	1805	1825	1846	1864	1884	1903	1922
90	1707	1726	1746	1766	1786	1806	1825	1845	1865	1884	1904	1923	1943
92	1726	1746	1766	1786	1806	1826	1845	1865	1885	1904	1924	1943	1963
94	1746	1766	1786	1806	1826	1845	1865	1885	1905	1924	1944	1963	1983
96	1765	1785	1805	1825	1845	1865	1885	1905	1925	1944	1964	1983	2003
98	1785	1805	1825	1845	1865	1885	1905	1925	1944	1964	1984	2003	2023
100	1805	1825	1845	1865	1884	1905	1925	1946	1964	1984	2004	2023	2043
102	1824	1844	1864	1884	1905	1924	1944	1964	1984	2004	2024	2043	2063
104	1843	1864	1884	1904	1924	1944	1964	1984	2004	2024	2044	2063	2083
106	1863	1883	1904	1924	1944	1963	1984	2004	2024	2044	2064	2083	2103
108	1883	1903	1933	1943	1963	1984	2004	2024	2044	2064	2084	2103	2123
110	1902	1922	1943	1963	1983	2003	2023	2043	2063	2084	2103	2123	2143

For Italians, add 130.

TABLE 14

PREDICTED BASAL METABOLIC RATES FOR ASIAN MEN

(Age 30, Temperature 70° F., Relative Humidity 75 per cent.)

Weight in kg.	Height in cm.												
	140	145	150	155	160	165	170	175	180	185	190	195	200
40	1231	1234	1236	1238	1240	1242	1243	1245	1246	1247	1248	1248	1250
42	1256	1259	1261	1263	1266	1268	1270	1272	1273	1275	1276	1276	1279
44	1280	1283	1286	1289	1291	1294	1296	1298	1300	1302	1304	1304	1307
46	1304	1307	1310	1313	1316	1319	1322	1324	1327	1329	1331	1332	1335
48	1327	1331	1334	1338	1341	1344	1347	1350	1353	1356	1358	1359	1362
50	1350	1354	1358	1362	1366	1369	1372	1376	1379	1382	1367	1385	1389
52	1373	1377	1382	1386	1390	1394	1397	1401	1404	1407	1410	1411	1416
54	1395	1400	1405	1409	1414	1418	1422	1425	1429	1433	1436	1437	1442
56	1418	1423	1428	1432	1437	1441	1446	1450	1454	1457	1461	1463	1468
58	1440	1445	1450	1455	1460	1465	1469	1474	1478	1482	1486	1488	1493
60	1461	1467	1473	1478	1483	1488	1493	1498	1502	1507	1511	1513	1519
62	1483	1489	1495	1500	1506	1511	1516	1521	1526	1531	1535	1538	1543
64	1504	1511	1517	1522	1528	1534	1539	1544	1549	1554	1559	1562	1568
66	1525	1532	1538	1544	1551	1556	1562	1568	1573	1578	1583	1586	1592
68	1546	1553	1560	1566	1573	1579	1585	1590	1596	1601	1606	1610	1617
70	1567	1574	1581	1588	1595	1601	1607	1613	1619	1625	1630	1634	1641
72	1588	1595	1602	1609	1616	1623	1629	1635	1642	1648	1653	1657	1664
74	1608	1616	1623	1630	1638	1644	1651	1658	1664	1670	1676	1680	1688
76	1628	1636	1644	1651	1659	1666	1673	1680	1686	1693	1699	1703	1711
78	1648	1657	1664	1672	1680	1687	1695	1702	1708	1715	1721	1726	1734
80	1668	1677	1685	1693	1701	1708	1716	1723	1730	1737	1744	1749	1757
82	1688	1697	1705	1714	1722	1730	1737	1745	1752	1759	1766	1771	1780
84	1708	1717	1725	1734	1742	1750	1758	1766	1774	1781	1788	1793	1802
86	1727	1737	1745	1754	1763	1771	1779	1787	1795	1803	1810	1815	1824
88	1747	1756	1765	1774	1783	1792	1800	1808	1816	1824	1832	1837	1846
90	1766	1776	1785	1794	1803	1812	1821	1829	1837	1846	1853	1859	1868
92	1785	1795	1805	1814	1824	1833	1841	1850	1859	1867	1875	1881	1890
94	1804	1815	1824	1834	1844	1853	1862	1871	1879	1888	1896	1902	1912
96	1823	1834	1844	1854	1864	1873	1882	1891	1900	1909	1917	1924	1934
98	1842	1853	1863	1873	1883	1893	1902	1912	1921	1930	1938	1945	1955
100	1861	1872	1882	1893	1903	1913	1923	1932	1941	1951	1959	1966	1977
102	1879	1891	1901	1912	1922	1932	1942	1952	1962	1971	1980	1987	1998
104	1898	1909	1920	1931	1942	1952	1962	1972	1982	1991	2000	2008	2019
106	1916	1928	1939	1950	1961	1971	1982	1992	2002	2012	2021	2028	2040
108	1935	1947	1958	1969	1980	1991	2002	2012	2022	2032	2042	2049	2060
110	1953	1965	1976	1988	1999	2010	2021	2032	2042	2052	2062	2069	2081

For Residual Mixed Group, add 60.

TABLE 15

Corrections for Temperature and Humidity

Men

Temperature (°F.)

	0	1	2	3	4	5	6	7	8	9
0	280	276	272	268	264	260	256	252	248	244
10	240	236	232	228	224	220	216	212	208	204
20	200	196	192	188	184	180	176	172	168	164
30	160	156	152	148	144	140	136	132	128	124
40	120	116	112	108	104	100	96	92	88	84
50	80	76	72	68	64	60	56	52	48	44
60	40	36	32	28	24	20	16	12	8	4
70	0	−4	−8	−12	−16	−20	−24	−28	−32	−36
80	−40	−44	−48	−52	−56	−60	−64	−68	−72	−76
90	−80	−84	−88	−92	−96	−100	−104	−108	−112	−116

Relative Humidity (*per cent.*)

	0	1	2	3	4	5	6	7	8	9
30	−135	−132	−129	−126	−123	−120	−117	−114	−111	−108
40	−105	−102	−99	−96	−93	−90	−87	−84	−81	−78
50	−75	−72	−69	−66	−63	−60	−57	−54	−51	−48
60	−45	−42	−39	−36	−33	−30	−27	−24	−21	−18
70	−15	−12	−9	−6	−3	0	3	6	9	12
80	15	18	21	24	27	30	33	36	39	42
90	45	48	51	54	57	60	63	66	69	72

TABLE 16

PREDICTED BASAL METABOLIC RATES FOR U.S.–N. EUROPEAN WOMEN

(Age 30, Temperature 70° F., Relative Humidity 75 per cent.)

Weight in kg.	Height in cm.												
	140	145	150	155	160	165	170	175	180	185	190	195	200
40	1084	1100	1116	1132	1148	1164	1180	1196	1212	1228	1244	1260	1276
42	1102	1118	1134	1150	1167	1183	1199	1215	1231	1247	1263	1278	1295
44	1120	1136	1152	1169	1185	1201	1217	1233	1249	1265	1281	1297	1313
46	1138	1154	1170	1187	1203	1219	1135	1252	1268	1284	1300	1316	1332
48	1156	1172	1189	1205	1221	1237	1254	1270	1286	1302	1318	1334	1351
50	1174	1190	1207	1223	1239	1256	1272	1288	1304	1321	1334	1353	1369
52	1192	1208	1224	1241	1257	1274	1290	1306	1323	1339	1355	1371	1388
54	1209	1226	1242	1259	1275	1292	1308	1325	1341	1357	1373	1389	1406
56	1227	1244	1260	1277	1293	1310	1326	1343	1359	1375	1392	1408	1424
58	1245	1261	1278	1295	1311	1328	1344	1361	1377	1394	1410	1426	1443
60	1262	1279	1296	1312	1329	1346	1362	1379	1395	1412	1428	1444	1461
62	1280	1297	1313	1330	1347	1363	1380	1397	1413	1430	1446	1462	1479
64	1297	1314	1331	1348	1365	1381	1398	1415	1431	1448	1464	1480	1497
66	1315	1332	1349	1365	1382	1399	1416	1432	1449	1466	1482	1498	1515
68	1332	1349	1366	1383	1400	1417	1433	1450	1467	1484	1500	1516	1533
70	1350	1367	1384	1401	1418	1434	1451	1468	1485	1501	1518	1534	1551
72	1367	1384	1401	1418	1435	1452	1469	1486	1503	1519	1536	1552	1569
74	1385	1402	1419	1436	1453	1470	1487	1503	1520	1537	1554	1570	1587
76	1402	1419	1436	1453	1470	1487	1504	1521	1538	1555	1572	1588	1605
78	1419	1437	1454	1471	1488	1505	1522	1539	1556	1573	1589	1606	1623
80	1437	1454	1471	1488	1505	1522	1539	1556	1573	1590	1607	1624	1641
82	1447	1471	1488	1506	1523	1540	1557	1574	1591	1608	1625	1641	1659
84	1471	1489	1506	1523	1540	1557	1574	1592	1609	1626	1643	1659	1676
86	1489	1506	1523	1540	1558	1575	1592	1609	1626	1643	1660	1677	1694
88	1506	1523	1540	1558	1575	1592	1609	1627	1644	1661	1678	1695	1712
90	1523	1540	1558	1575	1592	1610	1627	1644	1661	1678	1695	1712	1730
92	1540	1558	1575	1592	1610	1627	1644	1662	1679	1696	1713	1730	1747
94	1557	1575	1592	1610	1627	1644	1662	1679	1696	1713	1731	1747	1765
96	1574	1592	1609	1627	1644	1662	1679	1696	1714	1731	1748	1765	1782
98	1592	1609	1627	1644	1662	1679	1696	1714	1731	1748	1766	1782	1800
100	1609	1626	1644	1661	1679	1696	1714	1731	1749	1766	1783	1800	1818
102	1626	1643	1661	1679	1696	1714	1731	1749	1766	1783	1801	1817	1835
104	1643	1661	1678	1696	1713	1731	1748	1766	1783	1801	1818	1835	1853
106	1660	1678	1695	1713	1731	1748	1766	1783	1801	1818	1835	1852	1870
108	1677	1695	1712	1730	1748	1765	1783	1800	1818	1835	1853	1870	1888
110	1694	1712	1729	1747	1765	1783	1800	1818	1835	1853	1870	1887	1905

For Italians, add 100.

TABLE 17

PREDICTED BASAL METABOLIC RATES FOR ASIAN WOMEN

(Age 30, Temperature 70° F., Relative Humidity 75 per cent.)

Weight in kg.	Height in cm.												
	140	145	150	155	160	165	170	175	180	185	190	195	200
40	1073	1075	1077	1079	1081	1082	1084	1085	1086	1087	1088	1088	1090
42	1094	1097	1099	1101	1103	1105	1107	1108	1110	1111	1112	1112	1115
44	1116	1118	1121	1123	1126	1128	1130	1132	1134	1135	1137	1137	1139
46	1136	1139	1142	1145	1148	1150	1152	1155	1157	1159	1160	1161	1164
48	1157	1160	1163	1166	1169	1172	1175	1177	1179	1182	1184	1184	1188
50	1177	1181	1184	1187	1191	1194	1197	1199	1202	1205	1192	1208	1211
52	1197	1201	1205	1208	1212	1215	1218	1221	1224	1227	1230	1231	1235
54	1217	1221	1225	1229	1233	1236	1240	1243	1246	1249	1252	1253	1257
56	1236	1241	1245	1249	1253	1257	1261	1264	1268	1271	1274	1276	1280
58	1255	1260	1265	1269	1273	1277	1281	1285	1289	1293	1296	1298	1302
60	1274	1279	1284	1289	1294	1298	1302	1306	1310	1314	1317	1319	1324
62	1293	1299	1304	1308	1313	1318	1322	1327	1331	1335	1339	1341	1346
64	1312	1317	1323	1328	1333	1338	1343	1347	1351	1356	1360	1362	1368
66	1330	1336	1342	1347	1352	1357	1362	1367	1372	1376	1381	1383	1389
68	1349	1355	1360	1366	1372	1377	1382	1387	1392	1397	1401	1404	1410
70	1367	1373	1379	1385	1391	1396	1402	1407	1412	1417	1422	1425	1431
72	1385	1391	1398	1404	1410	1416	1421	1427	1432	1437	1442	1446	1452
74	1403	1409	1416	1422	1429	1435	1440	1446	1452	1457	1462	1466	1472
76	1420	1427	1434	1441	1447	1453	1460	1465	1471	1477	1482	1486	1493
78	1438	1445	1452	1459	1466	1472	1478	1485	1491	1496	1502	1506	1513
80	1455	1463	1470	1477	1484	1491	1497	1504	1510	1516	1522	1526	1533
82	1473	1481	1488	1495	1502	1509	1516	1522	1529	1535	1541	1545	1553
84	1490	1498	1505	1513	1520	1527	1534	1541	1548	1554	1560	1565	1572
86	1507	1515	1523	1531	1538	1545	1553	1560	1566	1573	1579	1584	1592
88	1524	1532	1540	1548	1556	1563	1571	1578	1585	1592	1598	1603	1611
90	1541	1549	1558	1566	1574	1581	1589	1596	1603	1611	1617	1622	1631
92	1558	1566	1575	1583	1591	1599	1607	1615	1622	1629	1636	1641	1650
94	1574	1583	1592	1600	1609	1617	1625	1633	1640	1648	1655	1660	1669
96	1591	1600	1609	1618	1626	1634	1643	1651	1658	1666	1673	1679	1688
98	1608	1617	1626	1635	1644	1652	1660	1668	1676	1684	1692	1697	1706
100	1624	1634	1643	1652	1661	1669	1678	1686	1694	1702	1710	1716	1725
102	1640	1650	1659	1668	1678	1686	1695	1704	1712	1720	1728	1734	1744
104	1656	1666	1676	1685	1695	1704	1713	1721	1730	1738	1746	1752	1762
106	1673	1683	1692	1702	1712	1721	1730	1739	1747	1756	1764	1770	1780
108	1689	1699	1709	1719	1728	1738	1747	1756	1765	1774	1782	1789	1799
110	1705	1715	1725	1735	1745	1755	1764	1773	1782	1791	1800	1806	1817

For Residual Mixed Group, add 40.

TABLE 18

Corrections for Temperature and Humidity

Women

Temperature (°F.)

	0	1	2	3	4	5	6	7	8	9
0	245	242	238	234	231	228	224	220	217	214
10	210	206	203	200	196	192	189	186	182	178
20	175	172	168	164	161	158	154	150	147	144
30	140	136	133	130	126	122	119	116	112	108
40	105	102	98	94	91	88	84	80	77	74
50	70	66	63	60	56	52	49	46	42	38
60	35	32	28	24	21	18	14	10	7	4
70	0	−4	−7	−10	−14	−18	−21	−24	−28	−32
80	−35	−38	−42	−46	−49	−52	−56	−60	−63	−66
90	−70	−74	−77	−80	−84	−88	−91	−94	−98	−102

Relative Humidity (*per cent.*)

	0	1	2	3	4	5	6	7	8	9
30	−118	−116	−113	−110	−108	−105	−102	−100	−97	−94
40	−92	−89	−87	−84	−81	−79	−76	−74	−71	−68
50	−66	−63	−60	−58	−55	−52	−50	−47	−45	−42
60	−39	−37	−34	−32	−29	−26	−24	−21	−18	−16
70	−13	−10	−8	−5	−3	0	3	5	8	10
80	13	16	18	21	24	26	29	32	34	37
90	39	42	45	47	50	52	55	58	60	63

TABLE 19

Age Adjustments, Per Cent.

Both Sexes, all Ages after 3 *Years*

	0	1	2	3	4	5	6	7	8	9
	—	–	—	8·1	7·8	7·5	7·2	6·9	6·6	6·3
10	6·0	5·7	5·4	5·1	4·8	4·5	4·2	3·9	3·6	3·3
20	3·0	2·7	2·4	2·1	1·8	1·5	1·2	0·9	0·6	0·3
30	0·0	−0·3	−0·6	−0·9	−1·2	−1·5	−1·8	−2·1	−2·4	−2·7
40	−3·0	−3·3	−3·6	−3·9	−4·2	−4·5	−4·8	−5·1	−5·4	−5·7
50	−6·0	−6·3	−6·6	−6·9	−7·2	−7·5	−7·8	−8·1	−8·4	−8·7
60	−9·0	−9·3	−9·6	−9·9	−10·2	−10·5	−10·8	−11·1	−11·4	−11·7
70	−12·0	−12·3	−12·6	−12·9	−13·2	−13·5	−13·8	−14·1	−14·4	−14·7
80	−15·0	−15·3	−15·6	−15·9	−16·2	−16·5	−16·8	−17·1	−17·4	−17·7
90	−18·0	−18·3	−18·6	−18·9	−19·2	−19·5	−19·8	−20·1	−20·4	−20·7

TABLE 20

PREDICTED BASAL METABOLIC RATES FOR BOYS

(Temperature 70° F., Relative Humidity 75 per cent., to be corrected for age)

Weight in kg.	Height in cm.												
	90	95	100	105	110	115	120	125	130	135	140	145	150
10	706	723	740	757	774	791	808	825	842	859	876	893	910
12	729	746	763	780	797	815	832	849	866	883	900	917	934
14	750	768	785	803	820	837	855	872	889	906	923	941	958
16	772	790	807	825	842	860	877	894	912	929	946	964	981
18	793	811	829	846	864	882	899	917	934	952	969	986	1004
20	814	832	850	868	886	903	920	939	956	974	991	1009	1026
22	835	853	871	889	907	925	943	960	978	996	1013	1031	1049
24	856	874	892	910	928	946	964	982	1000	1017	1035	1053	1071
26	877	895	913	931	949	967	985	1003	1021	1039	1057	1075	1093
28	897	915	934	952	970	988	1006	1024	1042	1060	1078	1096	1114
30	917	936	954	973	991	1009	1027	1045	1064	1082	1100	1118	1136
32	938	956	975	993	1012	1030	1048	1066	1085	1103	1121	1139	1157
34	958	977	995	1014	1032	1050	1069	1087	1106	1124	1142	1160	1178
36	978	997	1015	1034	1053	1071	1090	1108	1126	1145	1163	1181	1200
38	998	1017	1036	1054	1073	1091	1110	1129	1147	1165	1184	1202	1221
40	1018	1037	1056	1074	1093	1112	1131	1149	1168	1186	1205	1223	1242
42	1038	1057	1076	1095	1113	1132	1151	1170	1188	1207	1225	1244	1262
44	1058	1077	1096	1115	1134	1152	1171	1190	1209	1227	1246	1265	1283
46	1078	1097	1116	1135	1154	1173	1191	1210	1229	1248	1267	1285	1304
48	1097	1116	1136	1155	1174	1193	1212	1231	1249	1268	1287	1306	1324
50	1117	1136	1155	1175	1194	1213	1232	1251	1270	1289	1307	1326	1345
52	1137	1156	1175	1195	1214	1233	1252	1271	1290	1309	1328	1347	1365
54	1156	1176	1195	1214	1234	1253	1272	1291	1310	1329	1348	1367	1386
56	1176	1195	1215	1234	1253	1273	1292	1311	1330	1349	1368	1387	1406
58	1195	1215	1234	1235	1273	1293	1312	1331	1350	1369	1389	1408	1427
60	1215	1235	1254	1274	1293	1312	1332	1351	1370	1390	1409	1428	1447

TABLE 21

PREDICTED BASAL METABOLIC RATES FOR GIRLS

(Temperature 70° F., Relative Humidity 75 per cent., to be corrected for age)

Weight in kg.	Height in cm.												
	90	95	100	105	110	115	120	125	130	135	140	145	150
10	663	679	694	709	725	740	755	771	785	799	814	729	844
12	685	699	714	730	745	762	777	792	805	820	835	850	865
14	703	720	735	750	766	781	796	811	826	840	855	870	885
16	723	739	754	771	785	800	815	830	846	861	874	890	905
18	742	757	774	789	804	819	834	850	865	880	895	908	924
20	751	777	792	807	823	838	853	868	883	899	913	929	943
22	779	794	810	826	841	857	872	887	902	917	932	948	963
24	797	812	828	844	860	874	890	906	921	936	950	966	982
26	815	831	847	862	877	893	908	923	939	954	970	985	1000
28	833	848	865	880	895	910	926	942	956	972	988	1003	1017
30	850	866	881	898	913	929	944	959	976	990	1006	1021	1037
32	867	883	900	915	931	947	962	977	993	1009	1024	1039	1054
34	885	902	916	933	949	963	980	995	1011	1026	1041	1057	1062
36	902	918	934	950	966	982	997	1013	1028	1044	1059	1075	1091
38	919	936	951	967	984	998	1014	1031	1045	1061	1078	1092	1108
40	936	952	969	984	1000	1016	1032	1047	1064	1079	1095	1110	1125
42	953	970	986	1002	1017	1033	1049	1065	1081	1097	1112	1127	1142
44	970	987	1003	1018	1035	1050	1066	1082	1099	1113	1129	1145	1160
46	988	1004	1019	1036	1051	1068	1083	1099	1116	1131	1146	1162	1178
48	1004	1019	1037	1052	1069	1085	1100	1117	1132	1147	1163	1179	1194
50	1020	1037	1052	1070	1085	1101	1118	1133	1149	1165	1180	1196	1212
52	1038	1053	1070	1086	1102	1119	1134	1150	1165	1182	1198	1213	1229
54	1053	1071	1086	1102	1119	1135	1151	1166	1183	1199	1214	1230	1246
56	1071	1086	1103	1119	1135	1152	1167	1184	1199	1215	1231	1246	1263
58	1086	1103	1119	1136	1152	1168	1185	1200	1216	1232	1248	1264	1279
60	1103	1120	1136	1152	1168	1185	1201	1217	1232	1249	1265	1280	1296

TABLE 22

BASAL METABOLISM ESTIMATED BY DIFFERENT METHODS

CALORIES FOR 24 HOURS

O = Observed. P = Predicted

	No. of Subjects	Mean Age	Observed	Present Basis		Du Bois Table 44, p. 200		Brody $70.4\ W^{0.73}$		Kleiber $70\ W^{0.75}$			
								No Age Correction		No Age Correction		Age Correction 4 per cent. per Decade from Age 30	
				P	O : P	P	O : P	P	O : P	P	O : P	P	O : P
Lenti : Italian men	525	22	1629	1639	0·993	1580	1·031	1415	1·151	1528	1·066	1576	1·030
Stark : Wisconsin students	55	19	1747	1796	0·973	1841	0·949	1555	1·123	1683	1·038	1757	0·994
Miller and Benedict :													
Samoan men	21	25	1766	1718	1·028	1791	0·986	1628	1·085	1764	1·001	1799	1·047
U.S.–N. European men	155	22	1645	1677	0·981	1747	0·942	1483	1·109	1603	1·026	1654	0·995
,, ,, ,,	32	85	1305	1293	1·009	1390	0·939	1426	0·915	1539	0·848	1200	1·087
,, ,, women	48	45	1405	1384	1·015	1506	0·933	1516	0·927	1639	0·857	1541	0·912
Italian men	152	45	1686	1633	1·032	1614	1·045	1512	1·115	1635	1·031	1537	1·097
,, women	29	37	1419	1411	1·006	1391	1·020	1395	1·017	1505	0·943	1463	0·970
" Mixed " men	34	55	1402	1405	0·998	1396	1·004	1311	1·069	1412	0·993	1271	1·103
,, women	53	27	1211	1217	0·995	1305	0·928	1235	0·980	1329	0·911	1345	0·900
American woman	1	33	1633	1564	1·044	1689	0·967	1709	0·956	1855	0·880	1833	0·891
Italian man	1	20	1885	1847	1·021	1740	1·083	1605	1·174	1739	1·084	1809	1·025
Japanese woman	1	69	1022	1022	1·000	1080	0·946	1091	0·937	1169	0·874	987	1·035
Filipino man	1	48	1237	1253	0·987	1295	0·955	1126	1·099	1208	1·024	1121	1·103
Mean Percentage Deviation : Groups					1·5		4·2		8·5		6·1		5·9
,, ,, ,, : Individuals					2·0		5·4		9·5		8·9		6·8

TABLE 23

MEAN ANNUAL TEMPERATURE AND RELATIVE HUMIDITY

		°F.	R.H. per cent.
NORTH AMERICA			
CANADA:			
	Baffin Island	16·0	80
	Chesterfield Inlet	12·0	78
UNITED STATES:			
Massachusetts:	Boston	48·8	63
	Cambridge	48·0	70
	South Hadley	47·5	61
New England		48·0	70
Connecticut:		50·0	73
	New Haven	51·0	75
New York:	Buffalo	47·2	65
	New York City	50·0	60
	Rochester	46·0	72
	Syracuse	46·7	63
Pennsylvania:	Philadelphia	54·1	57
Ohio:	Cincinnati	52·0	68
	Columbus	52·1	52
	Ohio	53·0	70
Michigan:	Battle Creek	46·7	61
	Coldwater	44·0	70
Wisconsin		44·0	69
Minnesota:	Minneapolis	43·9	55
	Rochester	44·5	54
Illinois:	Chicago	48·7	61
	Urbana	50·9	56
Iowa		49·0	70
South Dakota:	Flandreau	45·2	51
Virginia:	Charlottesville	57·0	69
	Richmond	57·0	69
Kentucky:	Fort Knox	56·0	70
Missouri:	Columbia	57·5	70
Colorado:	Colorado Springs	49·0	58
	Denver	49·7	31
	Pike's Peak	19·3	60
Nevada		50·0	50
California:	San Francisco	54·9	79
South Carolina:	Charleston	66·1	58
Georgia		64·0	71
Oklahoma		61·0	65
Texas:	Lubbock	66·0	64
Louisiana:	New Orleans	68·4	62
Florida:	Tallahassee	67·7	57
CENTRAL AMERICA AND WEST INDIES			
MEXICO:	Chichen Itza	78·5	80
GUATEMALA		64·8	77
JAMAICA		78·8	79
CUBA: *	Havana	75·9	63
SOUTH AMERICA			
BRAZIL:	São Paulo	63·7	80
W. CHILE		61·3	89
EUROPE			
SWEDEN:	Stockholm	42·1	77
DENMARK:	Rönne	45·5	83
NETHERLANDS:	Amsterdam	47·5	83
UNITED KINGDOM		50·1	72
	Aldershot	49·7	70
	Hampshire	49·7	70
	London	49·7	67
	Oxford	49·5	69
	Glasgow	48·6	74
GERMANY		47·0	76
ITALY:	Turin	53·5	66
	Leghorn	60·0	66
	Rome and Carbonia	59·7	61
	Naples	60·4	69
	Baia	60·4	69
AFRICA			
ABYSSINIA:	Addis Ababa	59·0	65
	Harrar	68·0	62
	Mogadiscio	82·0	89
ASIA			
INDIA:	Nilgiri Hills †	66·5	75
	Madras	81·8	74
	Hyderabad †	77·0	72
	Bombay	79·3	77
	Calcutta	77·9	75
MALAYA:	Singapore	80·1	83
CHINA:	Mukden	47·0	70
	Peiping	53·5	64
	Chengtu	57·0	79
	Kweichow	59·9	77
	Canton	72·0	78
JAPAN:	Tokyo	56·8	77
PHILIPPINES:	Manila	81·0	79
NETHERLANDS EAST INDIES:			
Java:	Batavia	80·0	83
AUSTRALIA			
NORTHERN TERRITORY:	Hermannsburg and Cockatoo Creek†	70·0	47
NEW SOUTH WALES:	Walgett	67·9	51
	Sydney	63·0	69
VICTORIA:	Runnymede	63·0	69
POLYNESIA			
HAWAII:	Honolulu	75·2	75
SAMOA *		80·0	80

* From original paper.

† Humidity by interpolation.

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